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Health Benefits and Industrial Applications of Functional Cowpea Seed Proteins

*Alexandre Carneiro da Silva,
Marcos de Freitas Barbosa, Pedro Bento da Silva,
Janiffe Peres de Oliveira, Tatiana Loureiro da Silva,
Davair Lopes Teixeira Junior and Maurisrrael de Moura Rocha*

Abstract

Cowpea (*Vigna unguiculata*) is among the pulse's species of greatest economic and social importance. This legume is strategic for the food security and health of millions of people in the world. Cowpea is rich in nutraceuticals compounds such as dietary fibre, antioxidants and polyunsaturated fatty acids and polyphenols, whose health benefits and use in the food industry have been extensively studied. However, research on the identification of functional proteins from cowpea, their metabolic functions and applications in the food, health and other industries are still scarce. In this chapter, a critical review of the most recent and important research about functional cowpea proteins. We objective was identify and systematize information about the nature and functions of these proteins, as well as their use and applications in food, health and other industries. Cowpea seed proteins are highly versatile and offer direct health benefits such as reducing the incidence of cardiovascular disease and some types of cancer. The proteins of cowpea are also used in material science for the development of new technologies such as development of special fabrics for protection against ultraviolet rays and microencapsulation of ascorbic acid.

Keywords: pulse, essential amino acids, globulins, nutraceuticals, food industry, *Vigna unguiculata*

1. Introduction

The rapid increase in the cost of animal-based protein foods has increased interest in plant protein, especially from the before underutilized crops [1, 2].

The consumption of pulses (e.g., lentil, common bean, chickpea, and dry pea) generates positives impacts human and environmental health impacts, making them an ideal food for wise and conscientious global citizens [3, 4].

In fact, 2016 was declared by FAO as the International Year of Pulses, intending to heighten public awareness on the nutritional and health benefits of pulses, their biodiversity and climate changes adaptation, included in a sustainable food

production strategy designed to achieve food security and adequate nutrition [5]. In addition, pulses are a fordable and shelf-stable [4]. The American Pulse Association calls pulses the world's most versatile superfood [6].

Protein energy malnutrition (PEM) is one of the most severe public health problems in many developing countries [7]. Particularly, child malnutrition was associated with 54% of deaths in children in developing countries [8].

Cowpea (*Vigna unguiculata* L. Walp.) ($2n = 2x = 22$) [9] provides food for millions of people and is important in alleviating protein-calorie malnutrition [10]. Also is a good source of essential amino acids (e. g. Lys, His) and the aromatic AA [10, 11]. Because of its high crude protein content and a good balance of EAA, cowpea is usually considered as a complete food [12]. Cowpeas are also good sources of fibre, iron, zinc, and contain substantial amounts of bioactive compounds [13].

Cowpea has been promoted as a high-quality protein constituent of the daily diet among economically depressed communities in developing countries, with the aim of reducing the high prevalence of protein and energy malnutrition [14, 15]. Nutritionally, cowpea grain is the same as other pulses, with a relatively low-fat content and high total protein concentration [10].

Cowpea is a major alternative for the production of vegetable protein to be a culture of easy cultivation, low demand for soil fertility and adaptability and stability in all continents [16]. Cowpea ability to growth in low fertility and to subsist in soils where drought is a major constraint due to low and irregular rainfall confers advantages over other legume crops [17, 18].

Cowpea are also used as green manure, employed in a rotary schemewith other annual crops or in fruit plantations to increase or sustain soil fertility [19]. Dried cowpea seeds can be used for making cake or the seeds could be boiled, mixed with sauce or stew and consumed directly [20]. In addition to its great economic, social and environmental importance, cowpea is a crop with great industrial potential [21].

In the food industry, cowpea seeds is used in the production of canned and preserved foods, and in the production of isolated proteins with various applications (e.g. production or additives in flour, supplements for athletes and functional foods) [15, 19, 21–23]. However, a certain “underutilisation” of cowpea in food applications has been attributed to its beany flavour, presence of antinutrients and the hard-to-cook defect that prolongs cooking time [24].

The identification of the cowpea functional proteins and the investigation of the mode of action and application of these proteins aim to systematize information and contribute to the development of cowpea cultivation and the industrialization of this still underutilized culture, considering its great potential and studies already carried out in various areas of science.

2. Cowpea functional proteins

Vegetable proteins are presented as functional, as they provide health benefits, in addition to the essential nutrient's characteristic of the species. Functional properties of proteins are important in food processing and food product formulation. Some of these properties are water/oil binding, emulsification, foam capacity and gelation. These properties depend on characteristics of proteins such as molecular weight, amino acid composition, net charge and surface hydrophobicity [22, 25, 26].

Cowpea is a legume consumed as a high-quality plant protein source in many parts of the world [10]. It is characterized by having significant contents of proteins

(23–32%) and carbohydrates (50–60%), fibers, vitamins and nutrients, with a low-fat content (1%) and bioactive compounds, such as phenols and polyamines [27, 28].

Nutritional values and protein quality dependent on its amino acid composition, susceptibility to hydrolysis during digestion, purity and applied processing effects, such as heat treatments [29]. The nutritional and functional properties of pulses proteins depend on the nature of soluble fractions [12, 30]. Generally the protein content of cowpea differs along with the variety [12].

Cowpea has high protein and carbohydrate contents with a relatively fat-low content and a complementary amino acid pattern to that of cereal grains make cowpea an important nutritional food in the human diet [10]. Cowpea protein is rich in essential amino acids, particularly lysine, histidine and aromatic amino acids [31]. However, it is deficient in methionine and cysteine compared to animal proteins [32]. **Figure 1** shows the amino acid profile (essential amino acid) of cowpea protein.

The amino acid profile makes cowpea protein unique and of unquestionable quality [10]. The functional attributes of proteins like gelation, foaming, emulsification, thickening also drive the incorporation of isolated proteins in various foods like mayonnaise, baked foods and beverages [33]. The manner of converting the isolated proteins into powders also determines their functional properties [34].

In cowpea, protein types comprise globulins, albumins, glutelins and prolamins [12, 35]. Albumins and globulins are considered to represent the major storage proteins in cowpea [36]. Globulins represent most cowpea seed proteins and constitute over 51% of the total seed protein, while albumins approximately constitute 45% [37].

Glutelins have poor lysine content in cowpea [12]. Albumins has functional role in seeds as enzymatic and metabolic proteins (i.e. lipoxygenase, protease inhibitors and lectins) [38, 39]. Globulins has an important role as storage proteins and were mostly digested by proteases [38–40]. Prolamins are storage protein found mainly in seeds with high proline and glutamine content [41].

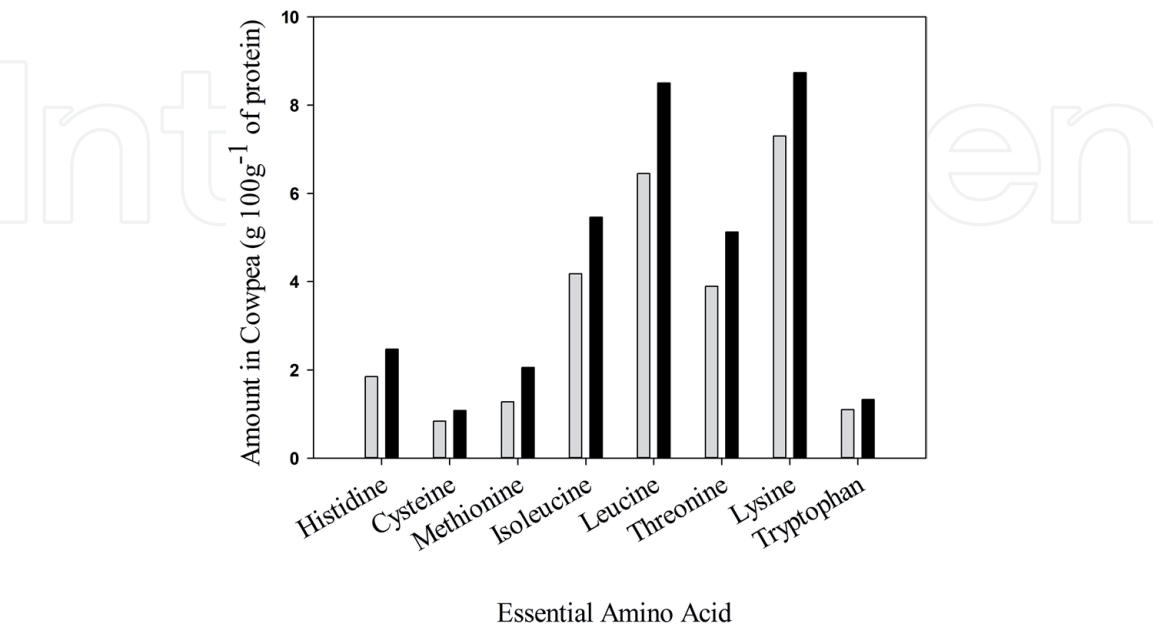


Figure 1. Essential amino acids profile of cowpea seeds. Black bars = upper values and gray columns = lower reference values found in the literature. Adapted from [10].

3. Benefits of functional proteins of cowpea seeds for health

Vegetable-based food systems are more sustainable than meat-based ones because they require less energy, land, and water resources [10, 19, 21, 26, 42]. Proteins from pulses has advantages in terms of sustainable development, nutritional properties, and health benefits [43, 44].

Cowpea is considered as an incredible source of many other health-promoting components, such as soluble and insoluble dietary fiber, phenolic compounds, minerals, and many other functional compounds, including B group vitamin, tocopherols (i.e. E group vitamin), anthocyanins and carotenoids [45–48].

Functional ingredients in cowpea that aid in weight loss [49], improve digestion and strengthen blood circulation also reports in the literature [50]. The low glyce-mic index of cowpea is attributed to the action of resistant starch and dietary fiber which attenuate insulin responses and reduce hunger [51].

Consumption of cowpea exerts protective effects against several chronic diseases [52], such as gastrointestinal disorders [50], cardiovascular diseases, hypercholesterolemia and obesity [53]. Cowpea has medicine properties, including anti-diabetic, anti-cancer, anti-hyperlipidemic, anti-inflammatory and anti-hypertensive properties [10, 42].

The therapeutic (or health) benefit of cowpea is principally attributed to its high protein, carbohydrate content as well as essential amino acids [54]. Cowpea proteins serve as an important ingredient in developing foods for all segments of population, however the functionality of proteins also assists in texture designing of foods [33]. Furthermore, consumption of cowpea and other grain legumes protein has been linked to reduce plasma low density lipoprotein, as well as incidences of cardiovascular diseases and some types of cancer [22, 55, 56].

4. Industrial use of cowpea seeds functional proteins

The cowpea is an annual pulses with high content of dietary protein rich in essential amino acids such as leucine, lysine, phenylalanine, tyrosine, aspartate, glutamate and arginine [11]. Their value as ingredients in food products is determined by their functional properties and nutritional characteristics [19].

Cowpea seeds utilization has been mainly limited to traditional uses [57]. Nevertheless, cowpea has the potential to become an industrial crop and the widespread consumption of convenience foods containing significant amounts of cowpea has substantially increased the demand for cowpea grain [22, 58, 59]. Due to the techno-functionality of its proteins, cowpea acts as an interesting ingredient [60, 61] for the food industry and others.

During the processing of cowpea seeds to produce ingredients (e. g. flour, isolated protein), there may be a breakdown or denaturation of legume proteins due to treatment conditions, including high temperatures, pH and osmotic potential [19].

These functional properties in cowpea seeds are influenced by environmental variables (e.g. temperature), pH and ionic strength during protein isolation and, also, during food processing, manufacturing, storage and preparation [31, 62].

Several methods of processing cowpea being studied, including treatment with temperature or high hydrostatic pressure in cowpea protein isolates. The modified cowpea protein isolates can be used in beverages because of the high solubility, in desserts because of the gel-forming ability and / or as additives in other foods because of the improved water holding capacity [19, 42].

Cowpea protein isolates (CPIs) can be used as ingredients and supplements [19]. It is not by chance that the food industry is the one that most industrializes

Protein	Action/aplication	Reference
7S and 11S globulins	Antibacterial agents	[66]
	Meat preservative	[13]
	Texture improvements in comminuted fish and meat products	
Cowpea isolates proteins (CPI's)	Applications for enhancing wettability and UV-Protection properties	[67]
CPI's	Antioxidants and aid in cancer prevention	[11]
	High potential as candidates for the therapeutic intrusion of cancer	[54]
CPI's	Microencapsulation of ascorbic acid (AA)	[51]
CPI's	Antifungal activity with application in bread	[68]

Table 1.
Identification and industrial application of cowpea proteins.

cowpea. In addition to high protein content, cowpea has proteins and functional peptides with different properties (e.g. gelafication and emulsification), molecular and non-molecular antioxidants, such as tochochromanols (i.e. different forms of vitamin E [63]), also important for the preservation of food and stabilization of several beneficial substances during the handling and packaging of processed food products produced with cowpea seeds.

Cowpea seed consumption is limited by their low digestibility, deficiency of sulphur containing amino acids and presence of antinutritional factors such as trypsin inhibitors, oligosaccharides (e.g. raffinose, trealose, staquiose) and phenolic compounds [10]. Adequate processing methods can be used to destroy those antinutritional factors, and improve the bioavailability levels [15].

A simple and inexpensive way to modify protein structure is to increase the pH of protein extraction during protein isolation. This treatment increases protein yield and influences chemical profiles of other compounds present in protein isolates [17, 64, 65]. In addition to the food industry, other industrial sectors have used and benefited from cowpea drinking proteins (**Table 1**).

5. Conclusions

Functional cowpea proteins are widely used in the food industry, which concentrates the largest number of researches. However, the use of these proteins in other industrial sectors, such as the medical and materials industry, which is still little explored, is beginning to grow. Future research should focus on the development and application of inputs and products for these industries.

Conflict of interest

The authors declare that there is no conflict of interest in the production and publication of this chapter.

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Author details

Alexandre Carneiro da Silva^{1*}, Marcos de Freitas Barbosa¹, Pedro Bento da Silva², Janiffe Peres de Oliveira¹, Tatiana Loureiro da Silva¹, Davair Lopes Teixeira Junior¹ and Maurisrael de Moura Rocha³

1 Federal Institute of Education, Science and Technology of Acre (IFAC), Brazil

2 Sacred Heart University (USC), Bauru, São Paulo State, Brazil

3 Embrapa Meio-Norte, Piauí State, Brazil

*Address all correspondence to: alexander.silva@ifac.edu.br

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